LF/M03

284

LIMITED CIRCULATION

This paper is not an official document; it is for information only and must not be quoted in any printed publication.

Agricultural Memorandum No. 1084

An Assessment of Objective Relative Humidity Forecasts as Required for Smith Periods

by M J Lee

SUMMARY

Fine and coarse mesh model humidity fields have been assessed in terms of their ability to predict relative humidity in the context of Smith Periods. A very limited set of data has been analysed for early 1987. The analysis indicates that some forecast skill is evident for Days 0 and 1. Success rates fall to the level of chance for Days 2 to 5; it is not yet clear how much of this deterioration could be reversed by improved spatial and temporal interpolation techniques.

FH2B.

1. Introduction

A Smith Period in the context of potato blight has occurred if, on each of two consecutive days, temperature does not fall below 10°C and the relative humidity is above 90% for at least 11 hours. An assessment has been made of how well these periods of high humidity can be predicted using the numerical model printfile output. To achieve a forecast out to 5 days ahead both the Fine Mesh (FM) and Coarse Mesh (CM) model data must be used: Fine Mesh out to T+36 hours; then Coarse Mesh out to T+120 hours.

2. Data Manipulation

The existing operational calculation of Smith Periods is based on hourly observations from about 150 synoptic stations across the UK. The coverage of the stations is such that their spatial precision is roughly compatible with their conversion to areal averages for 190 40 km x 40 km (MORECS) squares. It is onto this grid that the forecast relative humidities have to be converted, requiring interpolation in both space and time, as shown below.

	Fine Mesh	Coarse Mesh	Smith Periods
GRID	64 points at 75 km spacing	21 points at 150 km spacing	190 40 x 40 km squares
TIMING	3 hourly	6 or 12 hourly	hourly

The spatial interpolation is achieved by local surface fitting for each MORECS square using all land grid-points plus the first offshore points. The use of sea grid-points in some measure takes account of coastal effects when the wind is on-shore, but there is potential for the coastal relative humidities to be too high when the wind is blowing off the land.

The temporal interpolation is more difficult especially beyond T+48 when hourly relative humidities must be extracted from midnight and midday values only.

Relative humidity is a function of both the vapour pressure, e, and the air temperature, T_a:

$$RH\ (\%) = \frac{e}{e_s(T_a)} \times 100 \equiv \frac{e_s(T_d)}{e_s(T_a)} \times 100 \qquad (1)$$

where T_d = dew point temperature

$e_s(T)$ = saturation vapour pressure at temperature T.

Using the Magnus Equation, $e_s(T) = A \exp(BT/(C+T))$ (Abbott and Tabony, 1985) we can express equation (1) as (ignoring the factor of 100).

$$RH = \exp -\left[\frac{BC(T_a-T_d)}{(C+T_a)(C+T_d)}\right] \qquad (2)$$

where $B = 17.38\ °C^{-1}$

$C = 239.0\ °C$

and T is in °C.

Since $C \gg T_a, T_d$

$$\text{r.h.} \quad \exp\left(\frac{B\Delta T}{C+2T}\right) \qquad (3)$$

where $\Delta T = T_a - T_d$ and T is the mean air temperature over the day. Even assuming T_d to be constant (no air mass change) over the period of interpolation, the variation of RH is not linear, being particularly sensitive to temperature changes when the humidity is high (ΔT small). To construct a forecast diurnal evolution of RH would require a corresponding forecast of the daily evolution of air temperature (using the forecast periodic values of r.h. to establish T_d). At this stage such a level of detail is not included in the scheme and humidity is interpolated linearly, with the assumption that the midday and midnight values represent respectively the minimum and maximum diurnal values of RH.

Whilst interpolating the data there is an opportunity for biases to be removed from the model humidities, and if necessary for biases to be introduced in order to 'tune' the forecasts for the particular application of Smith Periods. That is, to achieve as high a success rate as possible in forecast Smith Periods (which depend on exceeding a threshold of humidity) rather than as low an error as possible in forecast absolute values of humidity.

3. Analysis Scheme

To establish how well the humidity component of Smith Periods is being forecast, data from the three months in the early part of 1987 have been examined, without any temperature criterion being applied. What is considered is whether the model was able correctly to predict 11 or more consecutive hours of relative humidity above 90% in a 09-09 day.

The ideal is for both the prediction of Smith Period and non-Smith Period weather to have as high a success rate as possible. By applying a multiplier to the relative humidities it is possible to shift the emphasis towards predicting Smith Period or non-Smith Period weather. A multiplier of greater than 1.0 will cause more Smith Periods to be forecast at the expense of non-Smith Period weather and vice versa for multipliers of less than 1.0. In theory the multiplier can be so high that all Smith Periods would be forecast, but this would also cause a large number of Smith Periods to be forecast when none actually occurred. This 'see-saw' effect is pronounced even when very small biases are applied to the humidities, as can be seen in Table 1. The figures give the percentage of occasions when Smith Period or non-Smith Period humidities are being correctly forecast.

In applying the multiplier to the humidities one philosophy that could be employed is to adjust it until equal percentages of Smith Period and non-Smith Period weather are correctly forecast. Alternatively, more emphasis could be placed upon the prediction of Smith Periods, ie to err on the side of caution based on the philosophy that missing a spray when the weather is suitable for Blight development is worse than spraying when

actually there was no need. Clearly care must be taken to avoid over-using this strategy to the extent that credibility in the forecasts is undermined.

4. Results and Discussion

In Table 1 are listed the percentage success rates for forecasting Smith and non-Smith humidity periods using humidity bias factors between 0.98 and 1.01. The results are sensitively dependent on the bias but factors different from unity simply trade success in forecasting Smith periods for success in forecasting non-Smith periods. Overall the use of humidities without any bias gives the 'best' results, based on the philosophy outlined above.

Totally random forecasts would achieve a 50% success rate under both Y and N headings, so Table 1 shows that measurable skill is apparent only in the first two days' forecasts, with performance falling to levels of chance by Day 2. This fall corresponds to the transition from the FM to the CM products with their coarser time and space resolution, but does not necessarily reflect a poorer quality of humidity forecast by the CM; the greater degree of interpolation may contribute a large amount.

The tendency for the forecasts to predict Smith conditions more successfully than non-Smith conditions is a fortunate one for the particular application of potato blight, since it accords with the farmer's

emphasis on security. (Ideally of course we would wish no bias to be present, but if a bias does exist then its preferred direction is towards not missing blight weather).

On a cautionary note the sample of data represented by **Table** 1 is biassed towards the winter months; the blight season on the **other** hand spans the summer months of April to August and it may be that different results would be obtained for those months. Certainly the distinction in forecast accuracy between Days 0 and 1 and Days 2 to 5 is not as marked in the April results as it is in the January and March results.

A visual inspection of the results indicate that when a Smith Period is consistently predicted from day 5-1 then one usually materializes. Many of the 'wrong' predictions occur on only one of the previous forecast days. Looking at the data in this sequential manner would yield better results, especially for multipliers of >1.0.

5. Conclusion

To predict Smith Periods the duration of high humidity must be forecast. Fine and Coarse Mesh models, however, predict grid point humidities for a particular time. In this analysis very primitive interpolation methods have been used to estimate duration from the model grid point data.

Some skill is apparent for the FM-based predictions for Days 0 and 1, but success rates fall to the level of chance by Day 2 when the transition to CM-based predictions is made. It is not clear at the moment how much of this deterioration is due to inherently poorer CM predictions and how much is due to the interpolation techniques. Overall it is encouraging that the model humidities do not seem to have a systematic bias.

The results are drawn from data for the winter/spring of 1987; it is possible that data for the summer months more appropriate to the potato blight season might yield different conclusions. This possibility will be investigated in the analysis of the trial Smith Period forecasts issued for ICI's 1987 campaign 'Blightwatch Southwest'.

6. Reference

Abbott P F and Tabony R C, 1985. The estimation of humidity parameters Met. Mag. 114 p49-56.

Any comments or suggestions on this paper should be referred to the author.

Met O 3c
Meteorological Office
London Road
Bracknell
Berkshire RG12 2SZ

May 1987

Table 1. Relative success rate of prediction of humidity periods both meeting, and failing to meet, the Smith criterion; similarly an entry under 'N' indicates relative success in predicting periods failing to meet the criterion. Totally random forecasts would be expected to achieve 50% success.

JANUARY 1987

RH MULTIPLIER	0.98		0.99		1.00		1.01		1.02	
FORECAST DAY	Y%	N%	Y%	N%	Y%	N%	Y%	N%	Y%	N%
0	67	65	75*	57*	80	50	83	47	-	-
1	48	61	56	53	61*	46*	66	40	-	-
2	36	60	45	52	53*	45*	63	39	-	-
3	35	63	44	54	53*	47*	60	40	-	-
4	44	64	51	56	59*	48*	65	42	-	-
5	37	64	44	55	51*	47*	57	41	-	-

MARCH 1987

RH MULTIPLIER	0.98		0.99		1.00		1.01		1.02	
FORECAST DAY	Y%	N%	Y%	N%	Y%	N%	Y%	N%	Y%	N%
0	-	-	63	65	70*	56*	75	48	-	-
1	-	-	47	57	57*	48*	66	41	-	-
2	-	-	34	55	44	46	51*	39*	-	-
3	-	-	35	53	44	45	53*	38*	-	-
4	-	-	33	52	43	42	52*	34*	-	-
5	-	-	43	56	51*	47*	58	38	-	-

APRIL 87

RH MULTIPLIER	0.98		0.99		1.00		1.01		1.02	
FORECAST DAY	Y%	N%	Y%	N%	Y%	N%	Y%	N%	Y%	N%
0	-	-	57	66	65*	56*	70	47	-	-
1	-	-	58	61	65*	51*	71	42	-	-
2	-	-	50	61	58*	51*	65	42	-	-
3	-	-	48	59	56*	48*	63	39	-	-
4	-	-	52	57	61*	47*	69	39	-	-
5	-	-	53	56	62*	46*	71	37	-	-

* 'Best' combination.